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ABSTRACT

This module is the eleventh in a series of eleven modules in an energy conservation curriculum for secondary and postsecondary vocational students. It is designed for use by itself or as part of a sequence of four modules on energy conservation in building construction and operation (see also modules 8, 9, and 10). The objective of this module is to train students in the recognition, implementation, and utilization of energy economics in energy consumption and possible energy conservation. First, an introduction to the module and definitions of key terms are provided. Next, the text is presented in the following four units: (1) energy use and demand profiles; (2) energy use and demand profiles in the home; (3) energy conservation methods and trade-offs; and (4) energy costing and accounting. The information in each unit is presented in lecture format accompanied by laboratory exercises and questions/examples for class discussion. A bibliography and several tables illustrating the text material are found at the end of the module. (BM)

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Energy Conservation Curriculum for Secondary and Post-Secondary Vocational Students. Module 11.

ECONOMICS OF ENERGY CONSERVATION

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CORSICANA, TEXAS

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April, 1979

MODULE #11

ECONOMICS OF ENERGY CONSERVATION

This module is one of a group of 11 modules in an energy conservation curriculum for secondary and post-secondary vocational students. Economics of Energy Conservation may be offered by itself or as part of a sequence of three modules in the following order:

Order	Module	Title of Module
1	8	Building Construction Versus Energy Consumption
2	10	Heating, Ventilating, and Air Conditioning Conservation Opportunities
3	11	Economics of Energy Conservation

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MODULE #11

ECONOMICS OF ENERGY CONSERVATION

MODULE DESCRIPTION:

This module is designed to be practical in nature discussing the cost of energy conservation measures and the savings and benefits in energy and dollars for implementing them. Initial and front-end costs are discussed in terms of payback periods and amortization of investment. The student will learn to develop an overall energy conservation plan by identifying energy usage savings through operational tradeoffs, cost of implementation, and prioritizing energy conservation measures. Auditing procedures for energy conservation are also discussed.

GOAL STATEMENT:

The objective of this module is to train secondary and post-secondary students in the recognition, implementation, and utilization of energy economics in energy consumption and possible energy conservation.

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MODULE #11

ECONOMICS OF ENERGY CONSERVATION

UNITS:

Introduction

I. Energy Use and Demand Profiles

II. Energy Use and Demand Profiles in the Home

- A. Appliances
- B. Lighting
- C. Energy Conservation for Cars

III. Energy Conservation Methods and Trade-offs

- A. Heating and Cooling -- Trade-offs
- B. Energy Heating and Cooling -- Conservation Methods

IV. Energy Costing and Accounting

- A. Costs for Insulation
- B. Developing Your Own Energy Conservation Priorities
- C. A Summary of Energy Conservation Methods

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MODULE #11

ECONOMIC OF ENERGY CONSERVATION

TERMINOLOGY

Absorption - a process whereby heat extracts one or more substances present in an atmosphere or mixture of gases or liquids, accompanied by physical change, chemical change, or both changes of the material.

Absorption Chiller - a refrigeration unit based upon absorption refrigeration.

Absorption refrigeration - cooling which is effected by the expansion of liquid ammonia into gas by water. Heat is the primary source of energy.

Active - when applied to building design, it refers to the mechanical movement of energy by the use of an external force of energy.

Air change - the movement of a volume of air in a given period of time; if a house has one air change per hour, it means that all the air in the house will be replaced in a one-hour period. Air changes are expressed in cubic feet per minute.

Air conditioning - the process of treating air to control its temperature, humidity, flow, and odor.

Ambient temperature - temperature of the outside air.

Attic ventilation - in houses, screened openings provided to ventilate an attic space. They are located in the soffit area as inlet ventilators and in the gable end or along the ridge as outlet ventilators. They can also consist of powerdriven fans used as an exhaust system.

Berm - a mound or small hill of earth, man-made.

British Thermal Unit (BTU) - the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit; a unit of heat roughly equal to the amount of heat given off by burning a kitchen match.

Building skin - the physical structure which encloses a building.

Bypass loop - a piping arrangement which bypasses or circles the flow of a heat absorbing medium around rather than through a piece of mechanical equipment.

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CFM - an abbreviation for cubic feet per minute.

Capacity - the usuable output of a system.

Centrified fan - a machine for moving a gas, such as air, by accelerating it rapidly outward in an impeller to a surrounding casing; generally of a scroll shape.

Change of state (phase change) - the change from solid, or gas to either of the other two.

Chimney effect - the tendency of air or gas in a duct or other vertical passage to rise when heated due to its lower density compared with that of the surrounding air or gas. In buildings, the tendency toward displacement (caused by the difference in temperature) of internal heated air by unheated outside air due to the difference in density of outside and inside air.

Coil - a cooling or heating element made of pipe or tubing.

Comfort zone - the ranges of indoor temperature, humidity, and air movement under which most persons enjoy mental and physical well-being.

Compression - in a compression refrigeration system, a process by which the pressure and temperature of the refrigerant is increased to allow for greater heat transfer.

Conduction - a process of heat transfer whereby heat moves through a material.

Convection - transfer of heat by movement of a fluid or gas.

Crack method - a method used in the calculation of air movement from the outside into an enclosed space. The method is based on the rate through one foot of crack between sash and frame or between door and frame.

DHW tank - abbreviated form for Domestic Hot Water tank.

Damper - a device used to vary the volume of air passing through an air outlet, inlet or duct.

Dehumidification - the condensation of water vapor from air by cooling below the dew point or removal of water vapor from air by chemical or physical methods.

Density - the weight per unit volume.

Diurnal cycle - the day-to-night change or cycle of natural phenomenon. An example is the variation of outdoor temperature throughout a twenty-four hour period.

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Dry bulb temperature - a measure of the sensible temperature of air (the one with which we are most familiar).

Economizer cycle - a cooling mode which uses cool outdoor air to offset heat gains in buildings rather than using an energy consuming cooling device.

Electronic air filter - the use of electricity to set up a static charge which can remove dust and other particulate matter.

Energy - the capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical; in customary units, measured in kilowatt hours (KWH) or British Thermal Units (BTU); in SI units, measured in joules (J), where 1 joule = 1 watt-second.

Enthalph - a measurement of the total energy content of the air. The total energy content is composed of both sensible and latent heat as measured by the dry bulb and wet bulb temperatures.

Evaporative cooling - lowering the temperature of a large mass of liquid by utilizing the latent heat of vaporization of a portion of the liquid; cooling air by evaporating water into it.

Flow rate - velocity at which a fluid travels, usually through an opening or duct.

Frequency of occurrence - the number of times a given event will occur during a given period of time.

GPM - an abbreviation for gallons per minute.

Greenhouse effect - the effect of the earth's atmosphere in trapping heat from the sun. The atmosphere acts like a greenhouse by admitting the sun's shortwave radiation but blocking the exit of long wavelength radiation re-emitted by the earth or other warned objects.

Heat capacity - sometimes called the thermal capacity, a measure of how much heat is required to raise the temperature of a specific quantity of material by a given amount.

Heat dissipator - the method of transmitting energy or power out of a system in the form of heat.

Heat exchanger - a device used to transfer heat from one medium to the other.

Heat gain - an increase in the amount of heat contained in a space, resulting from direct solar radiation and the heat given off by people, lights, equipment, machinery, and other sources.

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Heat loss - a decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, roof, and other building envelope components.

Heat pump - a reversible refrigeration system that delivers more heat energy to the end use than is put in to the compressor. The additional energy input results from the absorption of heat from a low temperature source--the combination heating and cooling unit. It operates like a normal air conditioner in summer, and in winter operates in reverse, ejecting warm air indoors and cool air (or water) outdoors.

Heat wheel - a device used in ventilating systems which tends to bring incoming air into thermal equilibrium with existing air. As a result, hot summer air is cooled and cold winter air is warmed.

Humidifier - a device to add moisture to air.

In-line pump - a pump which is supported by the piping system.

Incident - usually used in the term "incident radiation" which is the amount of energy striking a collector surface before entering the collector.

Infiltration - the uncontrolled flow of air into and out of a building through cracks, openings, doors, or other areas which allow air to penetrate.

Initial cost - the original price of an item or system.

Insulation, thermal - any material high in resistance to heat transmission that, when placed in the walls, ceilings, or floors of a structure, will reduce the rate of heat flow.

Kilowatt Hour (KWH) - unit of electrical energy consumption which equals about 3,400 BTU.

Latent heat - a change in heat content that occurs without a corresponding change in temperaure, usually accompanied by a change of state.

Peak load - maximum predicted energy demand of a system.

Perms-permeance - the ratio of water vapor flow to the vapor pressure difference of the surfaces; permeance is expressed in perms or (grains)/(Sq.Ft.)(Hr,), and of mercury vapor pressure difference.

Psychrometric - pertaining to the device comprising two thermometers, one a dry bulb, the other a wet bulb or wick-covered bulb, used in determining the moisture content or relative humidity of air or other gases.

R-value resistance - the resistance of a material to the flow of heat or energy.

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Reflectance - a property of a material indicating the percentage of light that is reflected when a certain amount of light strikes the surface of the material or is transmitted through it.

Relative humidity - the ratio of the amount of water vapor at a given temperature to the maximum amount of water vapor that could be held as vapor.

Sensible heat - heat that results in a temperature change.

Set back - the lowering of the thermostat setting. The technique is used to reduce the amount of heat required to heat a space.

Set up - the raising of the thermostat setting. The technique is used to reduce the amount of cooling required to cool a space.

Shortwave radiation - a term used loosely to distinguish radiation in the visible and near-visible portions of the electromagnetic spectrum (roughly 0.4 to 1.0 micrometers in wavelength) from longwave radiation (infra-red radiation).

Sling psychrometer - a psychrometer in which the wet and dry bulb thermometers are mounted upon a frame and connected to a handle at one end by means of a bearing or a length of chain. It may be whirled in the air for the simultaneous measurement of wet and dry bulb temperatures.

Solar intensity - the amount of solar radiation.

Solenoid value - a value actuated by a solenoid or an electronic impulse for controlling the flow of gases or liquids in pipes.

Space heating - interior heating of a building or room.

Stagnation - the condition of a fluid or gas unstirred by a current or flow.

Thermal comfort - the zone in which a majority of the human population would not feel too hot or too cold.

Thermal lag - the ability of materials to delay the transmission of heat; can be used interchangeably with time lag.

Thermal sensation - the ability of the body to sense the temperature as being too hot or too cold.

Time lag - the time between a cause and a resultant effect, as between occurrence of heat input on an exterior surface of a wall and the time until the heat is transmitted to the interior wall surface.

Ton (of air conditioning) - the thermal refrigeration energy required to melt one ton of ice (2,000 pounds); equals 12,000 BTU.

"U" value - a coefficient which indicates the energy (BTU) which passes through a component for every degree (Fahrenheit) of temperature difference from one side to the other under steady state conditions.

Vapor barrier - a component of construction which is impervious to the flow of moisture or air.

Vapor pressure - the force exerted when moist air attempts to seek equilibrium by migrating to areas with less water vapor.

Ventilation air - outside air that is intentionally allowed to enter an interior space.

Weatherstripping - foam, metal, or rubber strips used to form a seal around windows, doors, or openings to reduce infiltration.

Wet bath temperature - the lowest temperature attainable by evaporating water into the air, without altering the energy content.

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MODULE #11

ECONOMICS OF ENERGY CONSERVATION

UNIT I

ENERGY USE AND DEMAND

OBJECTIVES: Upon completion of this unit the student will be able to:

1. Discuss the prevailing American philosophy toward energy.

2. Explain the analysis of cash flow from income.

3. Discuss the difference between baseline load for utilities versus the instantaneous load demand.

4. Recognize the baseline load and peak demand periods during the year for natural gas and electricity.

5. Discuss the various forms of generating electricity for domestic use.

LECTURE

LABORATORY

INTRODUCTION

Our modern technical society runs on energy and the by-products of energy production. Life as we know it is impossible without the expenditure of both energy and resources. Each individual requires a certain amount of energy consumption or expenditure every day of their life depending on their interests, needs, and conservation practices, to support their lifestyle. This use of energy is either direct in the form of light, heat, and transportation, or indirect in the form of materials, food, products, and clothing utilized or consumed. There is no lifestyle or philosophy, including those alternative lifestyles and simpler technologies, which do not include some expenditure or use of energy.

The purpose of this module is to develop background knowledge and information that will be useful to individuals who are interested in determining, limiting and/or controlling their energy use. It will also help individuals to learn how they can minimize their energy impact on our society. How they can make energy policy decisions and use a planned approach to the consumption and conservation of energy. It is possible for most individuals to cut their energy use by a significant factor without having to lower their standard of living. In fact in many cases, energy conservation can raise one's life-style. Using the contents of this module they can make energy policy decisions with respect to their personal life. Thus, each of us can determine the use we will make of our energy dollars.

When one does an analysis of cash flow from their income, it is found that there are very few items in one's budget which are discretionary. The cost of paying for housing, baseline utility charges, and the expenses of employment are usually fixed. Discretionary income in the family budget lies principally in two areas. One of these is food and the second of these is energy. Unhappily in the past, many

Americans when caught in a declining cash flow situation with increasing food and energy prices, have chosen to cut into the part of the discretionary funds which are used for food. This leads to dietary problems, lower quality of life, cutbacks in activities, etc. The purpose of this module is to offer a second alternative for the reduction of discretionary expenses: namely, the conservation of energy use to reduce the size of utility bills and thus reduce the fraction of the total budget spent on energy as well as to reduce the dollars spent on energy. This reduction in dollars-spent can easily be an absolute reduction even in this time of rapidly rising utility rates. It should be noted that money spent on an individual for food is money spent on self, while money needlessly spent on utility bills is money wasted. However, it should be the basic philosophy of the people considering this module that unnecessary funds given

to the utility company for excessive energy purchases, which are not really needed and which should be saved by conservation, are monies that have been thrown away or might just as well have been scattered to the wind.

The utility companies confronted with rising power demands, increased pollution requirements, increased fuel costs, and greater potential for degradation of the environment, are caught in a bind between their required mandate as a power monopoly to provide power on demand and the fact that additional power is becoming progressively more expensive to produce. The utility company, because of the way utility equipment is financed, must not only pay for existing equipment, but must charge existing customers at such rates to make it possible to finance bonds, etc. which are sold to cover the costs of developing and bringing on new power plants. Thus, an individual's utility rates go up not only because of current cost increases, but because of expansion required by anticipated demand. In this module, we will look at a number of different aspects on energy conservation. These will include:

1. Energy use and demand profiles,
2. Energy conservation methods and trade-offs,
3. Energy costing and accounting,
4. Developing your own energy conservation priorities.

ENERGY USE AND DEMAND PROFILES

When a person turns on an electrical or gas appliance, they are the final users of an energy production process which begins where the raw resources are extracted from the earth or a natural energy source, such as falling water is harnessed. These resources are then processed for upgrading and standardization, such as in the case of natural gas, or they produce a final product such as electricity. The utility company has to provide, because of their monopoly privileges, power on the demand of their customers. This means that as each individual turns on and off the discretionary appliances in the house, and as the automatically controlled appliances,

LABORATORY

For the first activity, the students should get hold of a standard mineral reference such as the statistical abstracts of U. S. or material handed out by the teacher. The students should plot the demand for oil, natural gas, and coal, and for electricity as a function of year on graph paper or using a bar graph. A smooth curve should be fit through the demand value and the consequences of different growth patterns for the future should be discussed. As a second part of this activity, students should calculate the average power consumption for each individual in the United States. This should then be compared with the world's population to see what the power consumptions would be for the world if everyone used power the same level that the U. S. does. The average power consumption for different countries of the world will be attached to the activity for additional analysis.

such as furnaces, refrigerators, etc. cycle, the demand for power production by the utility changes. This individual demand summed up for each customer is the power requirements of a complete community and produces what is known as a load profile, or most commonly, the instantaneous power load. The actual time profile of the power demand consists of two major components. The first component, as shown in Figure 1, is the baseline load. This baseline load is the minimum constant demand that the utility has during any particular predefined period. The baseline load can be adjusted for daily, monthly, or seasonal demand anticipations. The baseline load is produced by utility generating facilities which run continuously. These include coal-fired boilers producing steam for the generation of electricity and in some parts of the country, nuclear systems. The other part of the demand is called the instantaneous load demand produced by the load following or instantaneous capacity of the utility system. The maximum value of the instantaneous load is called the demand peak. The instantaneous load is the part of the demand which changes by hour and by day. In general, demand peaks appear in the morning and in the evening. The actual size and shape of the demand peaks are a function of season, weather, the particular location you are looking at, and the characteristics of the clientele being served. A power company which has a large number of industrial and commercial clients will have a different load following curve or load profile. This peak load or peak demand has to be produced by power systems which can be turned on and off or brought on and taken off the power net over relatively short time intervals. Power systems which are capable of being turned on and off with short duty times are things such as hydroelectric generators, gas turbines, oil-driven turbines, and in some parts of the country, nuclear power plants have been used to produce the load following power and to meet the peak demand. Because of the fact that these other power plants are not used all the time they cost more per kilowatt hour of capacity to operate and

LABORATORY

Students, using their energy and mineral references should also look at the projected reserves of the various fossil fuels and natural resources. Using these as projected, they should determine the amount of time left for the use of each of these resources assuming that they are equally available down to the last percentage. This activity should be done for the following cases:

1. Steady demand at a current level.
2. An increasing demand of 5% per year.
3. An increasing demand of 10% per year.
4. An increasing demand of 15% per year.
5. A decreasing demand of 5% per year.
6. A decreasing demand of 10% per year.
7. A decreasing demand of 15% per year.

The upper exercises are to allow the student to see the consequences of different growth rates and increased power demands or projected growth rates and the consequences of reducing by conservation the demand for power. It should be noted that as the fuels disappear, there will be other consequences that are not foreseen in these simple exercises. Namely that it will take energy to convert coal to a liquid fuel and energy to convert coal to natural gas or other portable materials. Also, as one digs deeper into the earth for minerals or pumps on deeper wells or smaller reservoirs the amount of energy required per unit of energy extracted from the earth becomes greater. With respect to minerals, as the lower grade deposits are mined and worked and subsequently smelted, the energy required per unit production of metal or mineral increases. Increased energy costs per unit of energy coupled with growth in energy demand and cost means that you are multiplying increases in energy cost times increases in energy demand to give you non-linear energy and materials cost increases with time.

maintain, are less efficient to operate in most cases since they are used only for peak power production and high load demand periods. Because of the fact that they have to be turned on and off in short cycles or fairly rapidly, peak power production is much more expensive than baseline load power production per kilowatt hour. Nuclear power plants are used in some parts of the country for peak production because control rods can be inserted to reduce the rate of heat production fairly rapidly. However, the control rods do not completely stop the disintegration of the radioactive fuel in the core of the reactor. The chain reaction is only slowed down and the enhanced decays of individual radioactive nuclei continue. The decay rate being a function of the mean available neutron flux in the core with the control rods in place for standby operation of the facility. Therefore, a nuclear power plant, if it is loaded and has the control rods kept in, will itself still require a replacement fuel in the core at a predetermined time interval even if no power is ever produced. In general, peak power production for peak demand can cost 10 to 60 times what baseline costs when one compares the cheapest baseline plant to the most expensive turbine peak power following systems.

Current energy and power needs for the home in the United States can be summarized in Table 1. However, this is different from total U. S. energy consumption as shown in Table 2. Table 2 also shows percent of the energy lost as an absolute figure with respect to consumption and the percent of the amount used that is lost. Thus we see that 57.47% of residential energy use is lost or wasted. This loss will be what we address in this module.

Because of changes in demand with season, many parts of the U. S. have different power rates for summer and winter electricity. These rates vary not only because of demand, but because of the availability of fuel. An example of this in recent years was that in many parts of the Midwestern Northern U. S., the natural gas used in the winter for heating buildings, was used in the summer to produce electricity. Government changes in policy

LABORATORY

Students should proceed before a specifically assigned class to gather copies of at least one and preferably two years of utility bills used by their family. The actual dollar amounts are of no interest in this exercise. The student should get the kilowatt-hours of electricity and the thousand cubic feet of natural gas that were billed for each month from the receipts. It would be helpful also for the water consumption bills for the same period to also be tallied with respect to the number of gallons or number of cubic feet of water used.

In this activity, the students are to use graph paper to plot the monthly power requirements; namely the electricity and gas used, as a function of months of the year. They should put, per the example in Figure 2, of the months along the ordinate and the gas use up the right hand abscissa and the electric use up the left hand abscissa. If they also have water use information, that should be tabularly formed and analyzed to decide whether it should be included as well on the graph. If it was included on the graph one should put a second set of axes up the right hand side along with the gas use. This would be especially true for people who have all electric homes. Once this has been plotted the students should determine what the baseline loads are as a function of season and the overall yearly baseline load. This is the power demand at the minimum period during the whole year or the minimum power required for the period of either the winter heating or the summer cooling season. Students should also determine the peak profile structure and the peak demands for power.

This information will give them an idea of what power use demands are in their particular home.

and availability of fuels have required many utility companies to switch to coal-fired electric generators. These are going to cost additional funds to build and are going to require that the utility companies sell more bonds than normal demand increase requires. The consequences of this will be increased power plant construction, fuel demands, increased electric rates, etc. Thus, an individual should conserve for a number of reasons which have nothing to do with philosophy or alternative technology beliefs. Namely:

1. Conserving electricity will reduce the size of your immediate utility bill.
2. Conserving electricity will ensure reduced growth rates and thus a reduction in the cost per unit electricity on future bills.
3. Conserving electricity saves scarce, non-renewable natural resources.

The coal, oil, and natural gas being used to produce energy are characterized by two major facts. 1) They are highly concentrated forms of energy which are easily transportable and readily adapted to a large number of small power system usages, and 2) the fuels which are called fossil fuels, are in fact fossilized solar energy. These fuels are the result of pre-historic biomass produced by photosynthesis which captured the current available energy initially from the sun. The photosynthesis process has an efficiency of about 1% maximum. Obviously, the biomass that survives partial decay and compression into coal and oil, assuming both are produced from plant material, which would have a slightly less % of conversion efficiency. This coal and oil is then burned. In the case of the production of electricity, the maximum efficiency is approximately one-third. This means that you are, when burning fossil fuel, getting one-third of 1% of the incidence solar energy available converted into heat. Obviously, additional losses will reduce this figure by the time the electricity reaches your lamp or other appliance. If one takes natural gas and burns it directly in a boiler such as a hot water heater one gets approximately 68% energy conversion efficiency to heat. This means that in the case of gas, one gets 2/3 of 1% efficiency, minus plumbing and heating cycle losses. The water heater or a water heating

LABORATORY

Over a period of a couple of days each student should, after having learned in the previous sections to read an electric or gas meter, read the electric power and gas consumption on the smaller dials at hourly intervals for at least two days and plot this information. In periods of high demand use the student should read at fairly short intervals. This can be done for more than one season or for different types of weather days. Students can determine which appliances use large amounts of power by working as teams and either opening refrigerator doors, starting up the furnace or air conditioner by adjusting the thermostat, or waiting until they turn on to see how fast the meter moves and how much power is used per minute for the different types of appliances. The student can also leave a door or window open to see how infiltration rates increase the amount of time that a furnace runs.

boiler which is used to produce domestic hot water will cycle when cooled whether water is extracted and used or not. These finite inefficiently produced non-reproducable energy products when compared to possible overall efficiencies from renewable resources, are too valuable to be burned to produce heat, etc. Therefore, as a scenario in the transition from present power systems and power usage to the alternative systems which must be used as the resources of the world deplete, energy conservation is a necessary step to ensure that these irreplaceable resources survive long enough so that alternatives can be developed and put into use. One might note that oil products are used in the production of clothing, plastics and penicillin. These are much more valuable uses for oil than to burn it at approximately 1700°F to keep a house at 68-70°F.

LABORATORY

Using the data included in the laboratory module and class modules, they should determine what their expected power use is as a function of the appliances they use in their home. To do this, they should look at the hourly expected distributions and couple this with the watt and currents that they have taken off the electrical power consumption tags and stickers on the appliances used. This will be done using information covered in previous modules and class presentation. After having plotted what their actual energy use is, they should plot a scenario of what they believe a maximum energy use could be for their home. They should also plot an energy use reduction which follows the recommendations they have learned in this and previous modules. Students should then compare all three curves to find out whether they are a medium, a high, or a low power use compared between what they consider a maximum potential use and the minimum optimum use they have previously plotted.

UNIT 2

ENERGY USE AND DEMAND PROFILES IN THE HOME

OBJECTIVES: Upon completion of this unit the student will be able to:

1. Identify different appliances in the home and determine the cost of operation for each.

2. Determine the efficiency and cost of operation for various types of lighting.

3. Identify and discuss efficiency of an automobile.

4. Discuss energy conservation measures in handling, driving, and repairing an automobile.

LECTURE

A. APPLIANCES

Energy use in the home comes from a large number of different appliances and power devices. The devices listed in Tables 3 and 4 should cover most of the different appliances with their rated and expected power use and the average mean time of use that can be found in the average home assuming normal demand and use of the particular appliance. If one looks down the list and determines which appliances are used in a particular residence and multiplies the wattage by the time of use, the daily kilowatt or watt hours or watt seconds of use can be determined.

LABORATORY

An activity which can be used as a laboratory and demonstration exercise in the classroom consists of the following. One should take expected times for particular cooking processes or preparation processes and compare the time required for doing this in an oven, microwave oven, slow cooker, and counter top oven toaster using the information given in Tables 3 and 4.

ELECTRIC APPLIANCES

Electric Product	Typical Wattage	Cost	
Air Conditioner			
Room			
Bedroom	900	$ .028*	--hour
Family or Living Area	1500	.046*	--hour
Multiple Rooms	3000	.093*	--hour
Central (EER 8)**			
3 ton	4500	.112*	--hour
5 ton	7500	.187*	--hour
Baby Food Warmer	165	.0012	--10 minutes
Blanket	175	.03*	--night
Blender	385	.0003	--minute
Broiler (Portable)	1500	.031	--30 minutes
Can Opener	100	.00007	--minute
Carving Knife	92	.0003	--5 minutes
Clock	2	.06	--month
Coffee Maker	850	.0058	--10 minutes
Cooker (Egg)	516	.0017	--5 minutes
Curling Iron	40	.0004	--15 minutes
Corn Popper	575	.006	--15 minutes
Deep Fat Fryer	1500	.038	--hour
Dehumidifier	240	.0097	--hour
Dishwasher	1200	.029	--normal cycle
Disposer	420	.0003	--minute
Dryer	5000		
Regular Fabrics		.17	--load
Permanent Press		.13	--load
Electrostatic Cleaner	50	1.50	--month (continuous fan operation)

ELECTRIC HEATING**			
HEAT PUMP (JANUARY AVERAGE)	15000	.105*	--HOUR
BASEBOARD (JANUARY AVERAGE)	15000	.138*	--HOUR
FURNACE (JANUARY AVERAGE)	15000	.159*	--HOUR
FANS			
ATTIC	375	.0151	--HOUR
CIRCULATING	88	.0037	--HOUR
EXHAUST - SMALL	200	.0083	--HOUR
FURNACE (1/3 H.P.)	330	.0096	--HOUR
ROLLABOUT	171	.0070	--HOUR
WINDOW	200	.0086	--HOUR
FLOOR WAXER/CLEANER	350	.0145	--HOUR
FONDUE/CHAFING DISH	800	.016*	--HOUR
FREEZER (15 CU. FT.)	341	4.35*	--MONTH
FROSTLESS (15 CU. FT.)	440	6.10*	--MONTH
FRY PAN	1150	.03*	--HOUR
GARDEN TOOLS			
EDGER	190	.0039	--30 MINUTES
HEDGE TRIMMER	265	.0055	--30 MINUTES
GARAGE DOOR OPENER	350	.00024	--MINUTE
GRINDER (FOOD OR COFFEE)	150	.001	--10 MINUTES
GRIDDLE	1200	.019*	--30 MINUTES
HAIR CLIPPER	10	.00007	--10 MINUTES
HAIR DRYER			
SOFT BONNET	400	.0166	--HOUR
HARD BONNET	900	.0374	--HOUR
HAND HELD	600	.0249	--HOUR
HAIR ROLLERS	350	.0036	--15 MINUTES
HEAT LAMP	250	.0104	--HOUR
HEATING PAD	65	.0015*	--HOUR
HI-FI/STEREO	100	.00415	--HOUR
HOT PLATE	1250	.026	--30 MINUTES
HUMIDIFIER	175	.02	--DAY
ICE CREAM FREEZER	130	.004	--45 MINUTES
ICE CRUSHER	120	.00041	--5 MINUTES
IRON	1000	.0228*	--HOUR

Juicer	90	.00006	--minute
Knife Sharpener	100	.00035	--5 minutes
Lights*** - 100-watt bulb	100	.0415	--10 hours
Make-up Mirror	25	.00026	--15 minutes
Microwave Oven	1500	.005	--5 minutes
Mixer			
Hand	100	.0021	--30 minutes
Standing	150	.0031	--30 minutes
Motors****			
1/6 h.p.	170	.0004	--5 minutes
1/4 h.p.	250	.0006	--5 minutes
1/3 h.p.	330	.0008	--5 minutes
1/2 h.p.	500	.0012	--5 minutes
1 h.p.	1000	.0024	--5 minutes
Power Tools			
Drill (1/4 inch)	240	.0009	--5 minutes
Jig Saw	370	.00128	--5 minutes
Radio	75	.0031	--hour
Range			
Small Surface Unit	1300	.015	--15 minutes (high heat)
Large Surface Unit	2400	.009	--5 minutes (high heat)
Oven (non-self-cleaning)	3200	.043*	--hour
(self-cleaning)	3200	.034*	--hour
Broiler Unit	3600	.037	--15 minutes
Self-Cleaning Feature	4000	.15-.25*	--2 hours
Refrigerator/Freezer (14 cu. ft.)	330	4.16*	--month
Frostless	615	6.35*	--month
Roaster	1350	.034*	--hour
Sewing Machine	75	.0031	--hour
Shaver	14	.00005	--5 minutes
Shaving Cream Dispenser (Heated)	60	.00004	--minute

Slow Cooker - Low	75	.0031	--hour
High	150	.0062	--hour
Space Heater	1300	.054	--hour
Sump Pump (1/3 H.P.)	330	.0096	--hour
Sun Lamp	250	.0017	--10 minutes
Television			
Black & White	160	.0066	--hour
Solid State	55	.0023	--hour
Color	300	.013	--hour
Solid State	200	.0083	--hour
Toaster	1200	.0016	--2 minutes
Toothbrush	7	.000005	--minute
Trash Compactor	400	.0014	--5 minutes
Vacuum Cleaner	650	.027	--hour
Vaporizer			
Cool Mist	60	.0025	--hour
Steam	480	.0200	--hour
Waffle Iron	1200	.02*	--30 minutes
Warming Tray	140	.006	--hour
Washing Machine (Automatic)	500	.011	--Normal Load
Water Heater (Quick (Recovery)	4500	.10-.20	--per person/day
Yard or Post Lights			
175w Mercury (Bulb & Ballast)	196	.09	--night
100w Incandescent (Both based on photo-cell control--normal operating hours for one year -- 4,000)	100	.05	--night

Note: Costs exclude 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

** ELECTRIC HEATING AND CENTRAL AIR CONDITIONING COSTS VARY WITH EACH INDIVIDUAL HOME. MANY FACTORS ARE NEEDED TO ARRIVE AT AN ACCURATE ESTIMATE: SIZE OF HOME, TYPE OF SYSTEM, AMOUNT OF INSULATION, NUMBER OF DOORS, WINDOWS, ETC.

*** MANY FACTORS AFFECT LIGHTING COSTS: SIZE OF THE HOME, TYPE OF LIGHTING, ETC. BUT KEEP IN MIND -- FLUORESCENT LIGHTS ARE MORE EFFICIENT AND MORE ECONOMICAL TO OPERATE.

**** MOTORS FOR FURNACES, APPLIANCES, TOOLS, PUMPS, ETC. ARE RATED BY OUTPUT HORSEPOWER (H.P.), BUT DEPENDING ON SIZE, QUALITY AND LOAD CHARACTERISTICS THE WATTAGE RATING VARIES. IN GENERAL, 1 H.P. OUTPUT EQUALS 1000 WATTS INPUT AT FULL LOAD. HOWEVER, MOTORS ARE GENERALLY SIZED TO RUN AT 70% FULL LOAD.

TABLE 4

GAS APPLIANCES

Gas Appliance	Typical Gas Input Rating CFH	Cost	
Air Conditioners**			
Central 3 ton	80	.140*	--hour
Central 5 ton	135	.235*	--hour
Dryer			
Regular Fabrics	25	.062*	--load
Permanent Press	18	.050*	--load
Furnace**			
(January Average)	137	.073*	--hour
Outdoor Grill (Full heat)	25	.0242	--30 minutes
Range			
Surface Unit	6	.001	--5 minutes
Oven	30	.030*	--hour
Water Heater	37	.05-.10	--per person/day
Yard Light	2	.092	--day

Note: Cost includes both gas and associated electrical energy use for appliances, but excludes 3% sales tax.

* Thermostatically controlled. Cost based upon estimated percentage of "On" time.

** Natural gas heating and air conditioning costs vary with each individual home. Many factors are needed to arrive at an accurate estimate: size of home, type of system, amount of insulation, number of doors, windows, etc.

B. LIGHTING

Using the lumens information in previous modules, one should look at lighting requirements in the residence as a function of the ideal intensity levels of different activities. Considering the efficiency of illumination from incandescent and fluorescent bulbs, and evaluation of the power consumption needs of different types of lighting and lighting fixtures and the consequences of over-illumination can be illustrated. The consequences of using natural back lighting coupled with natural illumination for general low level minimal lighting or reading should be discussed as a consequence of the illumination levels. Because of the greater efficiency of fluorescent lighting, it is obvious that the use of such lighting in the ceiling and the use of lighting directly under the counter with the shortened distance is an energy use optimum procedure.

Table 5 gives the efficiency of energy conversion in the form lumens/watt of power consumed. As can be seen, incandescent bulbs or lamps are the least efficient. The mercury, metal halide, and sodium lamps are the most efficient, but require expensive fixtures and are not completely safe for indoor use.

When one discusses illumination and lighting, the intensity or light flux is inversely proportional to the square of the distance. This means that if one has light with a unit of 100 in intensity and one comes out one foot from that light one has an area that is 1 foot by 1 foot square one unit of density which will be set equal to 100. If one then comes out to a distance of 2 feet or 2 units one now has the light because of the direct ray pattern shown in Figure 3 spread over an area which is 2 units by 2 units along the edge or 4 square units of intensity. This means that the intensity of the unit area is one-quarter the amount at 2 feet than it was at 1 foot. The exact constant of proportionality is experimentally determined and the measurement at 1 foot can be used to set its value arbitrarily. If one comes out 3 feet, then the same intensity is spread over an area of 3 feet or 3 units of size giving you 9 square units that are being illuminated by direct ray analysis. This means that the intensity per unit area has now dropped from 100 to 1/9 of 100 or approximately 11.1%. Thus; indirect lighting and lighting at long distances from the working surface is dissipated with respect to proper lumen level by the distance light

Table 5

LAMPS - EFFICIENCY

TYPE	LUMENS/WATT
INCANDESCENT	8-22
FLUORESCENT	79
MERCURY	30-65
METAL HALIDE	70-95
HIGH-PRESSURE SODIUM	110

has to travel and dispersion of the light rays as they travel toward the working surface.

Fluorescent lighting, because of its greater efficiency of approximately 40% with respect to converting electrical energy into illumination, is much more cost effective for general lighting purposes. However, fluorescent light without careful reflection or concentration is not useful for high intensity close work. Therefore, in these cases, an incandescent bulb which has approximately a 12% efficiency with respect to converting electricity into illumination, is much more preferable for this type of work. Also, for general lighting where different levels are required for different activities such as in a hallway to a living room, a kitchen or other room where at one time one wants illumination of a level applicable for either close work or reading, while at other times one wants back lighting for other purposes than reading, it is more advantageous to consider the use of a mixture of light fixtures, one must determine how much the different options are going to be used. If one's primary use is close spot work, than an incandescent bulb coupled with a rheostat for turning down intensity for back lighting cases could be the most energy efficient option. This would be both in respect to money invested and with respect to the needed power use.

C. ENERGY CONSERVATION FOR CARS

In the case of cars, energy conservation can be broken down into two parts. The first part has to do with the efficiency of the car chosen. The second part has to do with the way the car is handled, driven, and repaired. In general, the lighter a car is in weight and the lower the air drag and cross-sectional profile due to smaller size, the more energy efficient it will run for any fixed engine. Fifty pounds additional weigh reduces mileage for large cars by about 1 mile per gallon of gasoline. The purpose of these modules are not to suggest that a particular type of car be bought, but that a person analyze their needs and buy no more weight, size and energy consuming options than are necessary in a car. After the weight has been chosen, one should note that if a person will not carry a lot of extra weight in the car in the form of personal accumulation, he will get slightly better gas mileage. In the second area, the way a

LABORATORY

Students should gather temperature data from newspapers for hourly rates, for mean daily highs and lows over a period of days. Using this data they should calculate the daily value of the temperature in terms of its heating or cooling degree days. They should also determine what the degree day values for particular temperatures and temperature changes are. This analysis can be done on a daily, hourly, or minutely basis depending upon the complexity of the data desired.

person drives is, for any particular car, a major determination of whether it gets high or low gas mileage with respect to it's EPA standard mileage rating. Mileage energy conservation tips are listed in the following paragraphs.

The second area in which energy conservation for automobiles, the importantce is in the maintenance of the car and the use patterns. These two are coupled because when a car is used basically for city driving where it is not allowed to reach temperatures necessary to dry out the exhaust system or remove from the oil and crankcase the moisture depleted from the gasoline, sludge builds up and oil. In this case, the oil filter should be changed more often to lengthen the lifetime of the car. Highway driving or driving that allows the car to reach sufficient temperatures to dry out the exhaust system and to raise the temperature of the engine sufficiently to prohibit production of carbon means that a person must change the oil and the oil filter less often when compared to all city driving. The times and mileage suggestions for these oil changes and other preventive maintenance are given in the car manufacturers manual provided for us, maintenance should be coupled with normal driving patterns.

Driving patterns are broken down into two basic types: those which have to do with the type of driving done, namely local, highway, etc. and into individual driving characteristics. The second area characteristically unique to each driver. Namely, does the driver accelerate slowly and carefully, does the driver have a tendency to change momentum or change velocity rapidly, are the brakes, clutch, or transmission used inordinately, does the person jack rabbit or tend to do drag race starts with the car, etc? Any one of these approaches which use a high acceleration or high change of velocity, momentum or speed in a short period of time, these are activities or sudden changes in the car's operating mode which tend to mechanically over torque the car's engine and drive train. These sudden rapidly wear out a car and also use much more energy. Long-term driving patterns, to be energy efficient, must be consistent and must be essentially of a defensive driving nature where one carefully plans move and does the minimum amount of acceleration change and fast breaking.

UNIT 3

ENERGY CONSERVATION METHODS AND TRADE-OFFS

OBJECTIVES: Upon completion of this unit the student will be able to:

1. Discuss two methods of energy conservation as trade-offs:

   a. Reduction of unnecessary use.
   b. Planned usage to reduce peak demands.

2. Identify trade-offs in utilizing heating and cooling equipment.

3. Identify energy conservation methods in heating and cooling equipment and operation.

LECTURE

LABORATORY

An individual on making a decision to engage in using the principles of energy conservation must know more than a little bit about the methods and trade-offs involved. One should be aware that not only is the direct use of energy in the form of lighting, heating, and cooking to be considered, but also the other energy costs that are represented by the provision or supply of hot water, water pressure, water purification, the maintaining of lawns, external lighting, etc. must be included in any detailed reasonable energy accounting scheme. Energy conservation methods consist of two major types: 1) reduction of unnecessary use and 2) planned usage to reduce peak demands. Energy conservation methods listed below and their trade-offs will in many cases fall into both areas. For any particular appliance or activity, conservation methods will reduce demand of energy necessary to operate that particular appliance. However, by shifting or limiting the number of appliances being used at any particular time or time sequence, one can determine the individual demand being made on the utility energy system. Let us consider energy conservation methods that have to do with heating and cooling first.

HEATING AND COOLING--TRADE-OFFS

Using climatic data from previous modules, the rough determination of optimum heating and cooling loads for the local area can be calculated and discussed. Using this data one can determine what the heating degree days or cooling degree days, on a mean value, are for a particular location. Heating degree day is defined in order to give a rough approximation of the expected heating power demand required as a function of mean hourly, daily, or monthly temperature. The heating degree day is defined on a base of 65°F for any mean predefined value or unit of time, by definition the heating degree day value is zero. However, if the temperature should be at a value of 64°F for a day or other defined interval, then that day (or interval) is one heating degree day given in °F days or other time units, if the interval considered is shorter than a day. If the temperature is 60°F on a particular day, as a mean value, then for that day the value is 5°F days or 5 heating degree days. This means that if temperature is 64°F for five days, one has five heating degree days. The heating load is determined by multiplying the number of degrees below 65 times the number of days for each particular temperature and then summing these up for a specified period of time. If, however, the temperature is 60°F for one day, this again, the number of degrees below 65°F times the number of days gives you 5°F days for the value for the measured heating load. This says in a mean degree value that amount of energy necessary to heat a house from 64°F to 65°F on five days is equal to the amount of energy necessary to heat the same house from 60°F to 65°F for one day.

Originally, the heating degree day reference temperature was 70°F and in some places considered higher. Therefore, one can see that by allowing the mean heating degree day reference temperature of 65°F to be lowered to 60°F one can define away the energy crisis and need for many parts of the Southern U. S. However, this could be a political and not a health decision. Under these conditions, 60°F heating temperature for interval living spaces, the comfort index will be reduced to a marginal level, but an absolute minimum power demand can be calculated.

However, if one decides to raise the cooling degree reference temperature from 70°F to 75°F or 78°F, then the consequences are not as great with respect to the comfort index. In regions where the humidity is low, as was discussed in the human comfort factor module, the comfort index is so defined that it measures human body comfort. Therefore, in regions where it is quite dry, higher temperatures of 80°F to 90°F are as comfortable as 70°F with 40-70% humidity. An example of this is in the desert southwestern United States where with a 5-10% relative humidity level, a temperature of 100°F feels like approximately 70°F with 60% relative humidity as far as the human body comfort is concerned. However, the individual will notice that it is necessary for them to drink more liquids, because the body is perspiring and the high levels of evaporation are working to cool the body. If energy conservation with human comfort are your only criterias, then one can allow the temperature of the conditioned space in the hot day regions of west Texas to raise greatly and still be quite comfortable with respect to the cooling degree reference temperature. As energy conservation becomes a major problem in this country, local comfort indexing of the temperature to the local climatology and mainly to the daily values of the local relative humidity should be seriously considered.

The other concept is the cooling degree day. The cooling degree day is currently defined as a measure of the number of degrees times the number of days that the mean temperature is above 70°F. In a similar manner to the heating degree day definition, if the temperature is below 70°F on a mean value, by definition there is no cooling degree day value or the cooling degree day value is zero. If the temperature is 71°F for one day, then for that day again the cooling degree day value is 1°F day. If the temperature is 80°F for one day, then it's 10°F times 1 day for 10 cooling degree days. Again, the cooling degree days for 1 day with a 80°F temperature and 5 days with a 72°F temperature are roughly equivalent for this type of general calculation. This obviously

Students should carry exercises of this nature out to find out what the expected savings would be by using energy conservation molds in their particular house by manual setting of the thermostats. The principles of heating and cooling systems are discussed in Module 10. The actual principles behind the systems does not have to be understood in complete detail to do conservation analysis.

is not always directly true since the heat flow is a gradient function and is a function of the temperature gradient per unit length and thus is a function of the temperature difference across the surfaces through which the heat is flowing. Calculating using the accuracy available in heating degree day information provides good baseline tool for "back of the envelope" type calculations.

These calculations can be used to determine within 10-15% what the expected power consumption will be for any particular building during the time defined by any particular period for which the degree day load has been calculated. It should be noted that the results from a mean cooling degree day for a day where the temperature reaches 80°F can be calculated using mean hourly, mean daily, or if someone wants high precision, mean minutely or quarter-hourly, data to calculate this quantity. The instructor should take representative data and show how one calculates heating and cooling degree days. Obviously, the more mean data used, the more information about direct gains and losses are averaged out of the system. Thermal time constants, thermal inertia, and thermal mass become important in determining whether the information lost by use of these simple calculation methods will add to the temperature swing or uncertainty in the building.

B. ENERGY HEATING AND COOLING--CONSERVATION METHODS

In order to talk about energy conservation methods for heating and cooling one must first consider the characteristics of the system with which one is dealing. The internal area of the home under the control of the heating, ventilating, and air conditioning system is the conditioned space of the building. The temperature can be maintained within this conditioned space by use of a number of possible systems or methods which include mechanical, active, passive, natural, and/or artificial. Any of these methods can be used to maintain the desired temperature and comfort index. The comfort index and comfort zone were discussed in previous modules. Within the conditioned space itself, there are three effects that must be understood in order to look at different methods for handling and reducing energy demands.

An energy demand audit should be done upon the house of the student or on the typical house that will be included in the material. A student is to look at the house and look at the way the walls are constructed to determine how many square feet there is of each wall type and the approximate wall construction r and u values discussed elsewhere in the modules is calculate what an expected heat loss would be for that house or a heat gain for that house for winter and summer use, assuming no direct solar gain. The direct solar gain activities is discussed in the module related to energy conservation methods and trade-offs is to be used to determine solar gain component of the picture. This should be enfolded then as a separate item to be either added or subtracted depending on whether the temperature desired inside the conditioned space is hotter or colder than its surroundings. Calculations of r and u values for the house as it now is and after the addition of more insulation, storm windows, and other heat flow inhibitors should be done before any changes are made to determine costs and benefits.

In general, for any objects above absolute zero, energy is transferred from a hotter surface to a colder surface by any one of a number of energy transfer mechanisms. These mechanisms are:

1. radiation
2. conduction
3. convection
4. forced convection

Radiation, which is the mechanism whereby the solar energy is transmitted by the sun to the earth, is the result of energy being radiated from one body to another. The radiation laws are known as Stefan-Boltzemann Laws which say the flux per unit area is directly proportional to the temperature to the fourth power. All generation techniques and methods are based on reducing the power needed to maintain a system by reducing the losses and gains from the conditioned space to the surroundings. These losses are reduced by the reduction in the three forms of energy transfer mechanisms. These energy transfers or heat conduction methods have been discussed in previous modules.

Human comfort in any particular area is a result of the loss from the skin compared to the amount of heat internally generated within the body. This means any one of a number of methods including clothing, higher temperature air, materials and radiant heaters, etc. can be used to maintain body comfort. When the human body at its higher temperature is radiating more heat to an unprotected or unshielded lower external temperature the body loses heat. The amount of heat lost depends upon the temperature difference, the number of heat loss retarding clothing layers, and the activity level of the individual. Therefore, the comfort region for activities is much different than that for at rest. This means that in general a person should look at the activities to be carried out at the time of day, etc. to determine what temperature should be maintained within the conditioned space. Personal preferences should also be considered at this point. But it should be noted that it is a lot easier and much more inexpensive to wear sweaters, heavier clothing, and multiple clothing layers than it is to heat a complete building. Using

the principles of clothing discussed in ther modules, it should be obvious that what person is doing is making a microclimatology around himself/herself by the process of utting on clothing layers for the purpose of rapping the heated air at the surface of the ody or by reducing the needed cooling levels by letting body heat escape or by controlling he rate at which the heat or hot air is lost. he comfort index or the comfort ratio can be adjusted according to season, activity, and ndividual need. Let us list a number of nergy conservation methods which can be used to reduce the energy costing in a particular uilding.

1. Controlled infiltration rates -- Infiltration is defined as the rate of air flow nto or out of a structure. This air flow is aused by pressure differences, wind, breeze, and the opening and closing of doors, vents nd windows in the building. Minimum infiltration levels are required in most building codes. However, most buildings, especially houses, have much higher infiltration rates than are equired. One of the major causes of infiltration is the fact that house air is burned in the furnace and is exhausted up through the ent or flu. This leads to a pressure difference f a few pounds per square inch. However, a few pounds per square inch of pressure difference as enough force if contained to raise a 2-3 nch concrete slab. Thus, a slight pressure difference provides a terrific drive gradient to force air through the walls of the building nd into the house. This means that you spend a large amount of your fuel dollars in heating outside air which then goes up the chimney. he air enters through cracks around doors, through window facings and through any place in the building which is not airtight. f one wants to reduce infiltration rates, ne of the easiest methods is to fix a furnace which is in the conditioned area f the house so that it draws its burning ir from the outside. However, this type of modification should be done by a licensed eating, ventilating, air conditioning contractor. When infiltration rates have been educed by removal of the furnace pressure difference by caulking, by storm windows, y sealing the house and controlling the wind ressures, then a person can control the infiltration rate by the use of the exhaust fans o meet the necessary comfort levels.

2. Controlled direct gain rates -- Direct gain is an advantage in the winter and a disadvantage in the summer with respect to the heat load on the building. Direct gain is the heat that penetrates the wall and radiates into the room plus that which comes through the windows, is absorbed in the internal surfaces, and reradiates itself into the structure. The direct gain through the walls is more commonly known as thermal time lag. This method was the basis for Adobe and Pueblo Indian construction in the Southwestern United States. For massive walls of adobe, the temperature time constant is such that in the evening when the atmosphere cools off in the desert southwest, the heat that has been entering the walls due to the direct solar illumination and from the hot air warmed with solar energy was absorbed as heat into the wall raising the internal temperature. The time constant for thick adobe walls is such that the remnants of this absorbed heat, not dissipated in the wall mass have now reached the inside radiating into the rooms to warm them. Traditional direct gain is defined as energy coming through the window which is absorbed in the inside of the structure. Obviously, this is an advantage in the winter and a disadvantage in the summer. Therefore, one should reduce the direct gain during the day in summer by insulating shades, awnings, etc. Also, at night in the winter the direct gain or the convective and radiative losses can be reduced by putting some sort of insulated shutter up. Direct gain, however, has one disadvantage, the ultraviolet in sunlight does fade colors, break down fabrics, and cause disintegration of many upholstery and furnishing fibers.

3. Controlled conductive losses through the walls or through thermally transparent surfaces -- Standard insulation techniques for walls and ceilings are discussed in a previous module. These methods should be applied in conjunction with storm windows and storm doors. Attic insulation should, in general, be added first. The savings to be realized by insulation, storm windows, etc. will be discussed in a later section. One can control the conductive loss through a thermally transparent surface by the use of storm windows, insulated shades, and the use of moveable insulation in the form of bead walls, shutters, and related types of materials.

The important thing with controlling those conductive losses through thermally transparent surfaces is that when the temperature gradient is in the wrong direction with respect to the conditioned space one reduces the conduction by increasing the insolation or the R value of the materials so that less heat flows through the thermally transparent surface which is predominantly window glass. Glazing materials in general have very low R values and thus contribute to high heat losses or gains depending on the season. Thus with the proper control of the insulation over glazings, it means that in the summer time the heat is kept out and the cold is kept in, and in the winter time the cold is kept out and the heat is kept in. This amount of savings depends on where one is located in the country. The moveable thermal barriers or moveable insulation are essentially closed in the daytime in summer and open at night, and open in the daytime in winter and closed at night. This assumes, of course, that one is not concerned about the other problems discussed with respect to solar ultraviolet radiation and its effect on furnishings.

4. Increase the thermal mass and thermal inertia of the walls by the installation of insulation either in the form of mass or reflective insulation. This change in thermal time characteristics is a different effect from strictly the "R" value insulation effects. These are dynamic effects and must be determined using "U" values.

5. Adjust overall infiltration surges and pulses by the use of air locks -- Rooms on both ends of the house such as an enclosed vestibule with paired doors, or utility room with paired doors can be used to reduce the overall infiltration surges and pulses. This is done with the air locks or double doored vestibules and rooms installed, by the simple process of entering the room or area and closing the outer door before opening the inner door and doing the reverse when leaving. These rooms are in general not heat or cooled to the temperature of the rest of the house and may have no direct heating or cooling except when required by climatic constraints and extremes. The heating would

be required only if there are present such things as water pipes in utility rooms or other types of material which might freeze. This restricted heating, cooling or conditioning of the space means that less energy is used to maintain this space at a minimum level and that the temperature gradient between this space and the outside world is less. Therefore, when one opens the door to leave or enter, the shock or surge or pulse on the conditioned space of the inside of the rest of the house is much less and is controlled by the volume of the room and in all cases is much less in temperature and amount to that which would be the case is the outside door was opened directly. This is especially important for high temperature differences, high humidity differences in the case of air conditioning, and for cases where there are high winds.

6. Hot water heaters -- Temperature reductions on a hot water heater save significant amounts of energy. If one is repiping a house, a small-piped high pressure system will also reduce heat losses. One should wrap and insulate both the hot water pipes and the hot water heaters, also to save energy one should reduce the settings of the control thermostat, temperatures from 150°F to 130-135°F. This coupled with insulating the water heater can save 35-40% of the bill compared to the bill for the higher temperature and no insulation. When a person is gone for more than 2 days, the water heater should be turned down to pilot or off if it has an electric ignition. The energy needed to reheat the water tank after returning will be less than the energy required to maintain temperature while the house is empty. In general, the heat from a hot water heater and other appliances such as small furnaces, dryers, stoves, etc., should be vented out in summer and captured in winter to reduce conditioning costs.

7. Plan meals in an organized manner and use leftover pre-planning to reduce the amount of food that needs to be cooked. Alternative use of ovens and countertop appliances to reduce cooking energy demands. Consider microwave ovens for small energy use products. Stovetop appliances and countertop appliances are most useful for special jobs. Consider pressure cookers as an option in preparing food.

8. Dishwashers -- Drying cycles in dishwashers can be eliminated, rewired to off switches and saved for special cases, or machines can be purchased with energy saving controls so that where it's necessary to heat up dishes or to dry in a hurry under crash situations, the option is still available. In general, air drying of dishes, pots and pans, etc. is much more sanitary and certainly uses a lot less energy either in the form of drying in the dishwasher or the washing and drying of dishtowels.

9. Use more recyclable materials such as cloth dishcloths, dishtowels, rags, etc. instead of paper and other products. Even though the paper itself is a renewable resource, much energy is spent in processing it and removing the pollution products from the effluents which have to be discarded.

10. Reduce the flow of toilets to what is minimally necessary by separate partitions, etc. These partitions will save water and thus energy not only on the front end with respect to purification, but also with respect to processing of sewerage, both of which consume energy.

11. Zonal living should be considered as an option for the peak energy conditioning lower demand months. House organization should be structured to take advantage of siting internal use, possible renovation, and energy lowest reduction as well as positioning current utilities and other heat sources.

12. It should be noted in general that vegetation layers against building surface walls do effectively increase the resistance of that wall to thermal losses. These are done basically by decreasing the sensitiveness of the boundary layer of the wall to temperature changes due to breezes and solar heating. Changes in the temperature of the air in the boundary layer of the wall with changes in the external environment will determine the temperature difference and thus heat flow through the wall. One wishes to reduce or control the detrimental extremes in the boundary layers.

These changes are predominantly in temperature and velocity, though they can include radiation enhancement or heating. Therefore, the bushes should be trimmed to grow as high as possible and cover as much of the wall as possible, especially on the north and on the west and south sides of the building where one wishes to reduce heat loading in summer from the sun and cooling of the structure in winter by winds.

The maintenance of the lawn should also be analyzed to minimize the time and energy involved, though this will be hopefully a minor improvement. While equipment such as power mowers, etc. are running they are consuming energy. Therefore, cutting patterns which are involved or plantings which involve a large amount of specialized cutting, backing, and turning should be avoided if one's main criteria is energy conservation. It should be noted that when one has a one-story slab house with the ground level slab, the trimmings from the lawn and from the leaves from the trees can be used to mulch under these bushes up against the house and thus to help to isolate the slab and near surrounding ground from temperature stresses due to diurnal changes of temperature. It should be noted that the slab itself should be insulated using appropriate insulation materials, but if one has mulch under these bushes, and maintains this for a fair distance out from the building, this will insure that the ground will not heat up or freeze right up to the building. It should also be noted that the temperature difference will be over a larger length and thus the gradient, the driving force of heat flow, will be reduced. Also, the ground around the building heats up with the sun depending on the bare surface. Not only does this heat the ground in the summer and thus heat up the area under the foundation, but it also helps dry out the soil and this region will to maintain stability and position of the slab require additional watering since mulch not only maintains the ground as cool but it also maintains water levels. Thus in both cases the transpiration rates are reduced and the watering requirements are minimized. Along the lines of maintenance, it should be noted that watered lawns which are maintained at grass heights which are at or near the upper level of the optimum length of a region, will require in general less watering to maintain them during times of stress. It is the cutting of the leaf of the grass which is the most stressful activity on the plant and when one cuts it short and cuts it frequently, watering

is much more necessary to insure proper recovery and new growth. Also, short cutting will expose more of the ground area increasing the amount of transpiration.

13. Attics, wind turbines, wind fans, natural convection, thermal chimneys, etc. -- These items are used generally to exhaust attics and not to move air. The purpose of an attic is to keep the heat generated by the solar intensity beating on the roof and of the living space by providing a thermal barrier which is readily accessible or exhaustible, and thus reduce the heat flow into the living space. The naked or insulated unfinished attic provides thermal insulation, but in southern climates and moderate mid-latitude climates it is not uncommon for an attic to reach 120°F on a moderately warm day where the external temperature is less than 90°F. This means that if you are conditioning the internal space at 75°F, you have a 45°F temperature difference across the ceiling. The temperature gradient determines the heat flow, therefore, a high gradient in temperature will produce a high heat flow. If one exhausts the attic by use of one of the above devices, preferably wind turbines, wind fans, or properly sized thermal chimneys to move enough air to stratify the temperature in the attic, then the temperature at the floor of the attic or ceiling of the living space is reduced and the heat flow also reduced. This means that the temperature at the peak or top of the attic will reach 115-120°F, but at the ceiling level, because the vents are located in this region, the temperature is only about 80°F or approximately 5-10°F above outside temperature, which is higher. This stratification means that the temperature difference is now only that between the inside and outside temperature plus a 5-10°F boost. Thus, heat flow into the room through the ceiling is reduced.

14. Space heaters -- Space heaters generally are very inefficient heating sources when applied to large areas. However, for zonal heating or pre-heating of bathing or dressing areas, when the rest of the house is maintained at a lower temperature level, a space heater can provide local temperature improvement and comfort. Optimum use of these space heaters can greatly reduce overall energy use when one is trying to conserve by zonal living and manual overriding on the temperature adjustments. However, space heaters do not replace conventional heating and air conditioning units.

UNIT 4

ENERGY COSTING AND ACCOUNTING

OBJECTIVES: Upon completion of this unit the student will be able to:

1. Determine energy costs versus efficiency of operation for appliances.

2. Determine cost investment and savings for insulation materials.

3. Determine payback periods for conservation measures as opposed to various types of conventional fossil fuels for heating.

4. Determine and prioritize retrofit measures for energy conservation in the home.

LECTURE

LABORATORY

A. COST FOR INSULATION

** The cost of energy consists of both the current costs of running an appliance or a facility, plus the capital costs of producing and installing said item. This is particularly important with respect to energy conservation and retrofit costs for housing. Namely insulation, storm windows, etc. With respect to the projected growth in energy costs in real dollars as compared to current energy costs, the amount of money to be spent will increase with time as these energy costs increase. The capital cost of a particular appliance must be considered along with the lifetime energy cost to determine how effective the savings will be on a particular appliance or energy using item. This means that if a person buys a refrigerator for $300, which in its lifetime uses $1600 worth of electricity, a saving can be made even if the money must be borrowed at current interest rates, if someone buys a $400 refrigerator which in its expected lifetime of approximately 16 years, for which the cost of electricity lies between $1000 and $1200. This $400-$600 energy savings, possible over the lifetime of the appliance, will more than pay for borrowing the extra $100 to buy the more efficient appliance. Therefore, a person needs to do calculations on the wattage and energy use to determine how much it is going to cost them to run a particular item or appliance. The data from the other

modules, including meter readings, how to read an electric or gas appliance tag, and how to determine bills for electric and gas usage are directly applicable to the study of this problem.

Using the information on "R" and "U" values for various materials, persons should calculate on baseline data the present heating and cooling loads for their home. The exact methods for these calculations have been done previously. After the basic "R" values, "U" values equivalent has been determined for various segments of the building, one can either calculate the loads as a function of specific months or reasons using mean heating or cooling degree data. This information provides a basis for the current load values for the house. One then determines the BTUH load for the structure for monthly and design degree days for both the heating and cooling season. Using the calculated BTUH data for the house, one can then determine the amount of energy needed and the cost. To do this, the information from Table 5. One first must convert the energy need into power requirements using the equipment efficiencies. This will give one a measure of the BTU totals needed to provide the BTUH values or BTU sums required to satisfy the heating or cooling load. Dividing by the heat content of the fuel will give one a measure of the amount of energy needed in the form of fuel to maintain comfort conditions. Multiplying the result of the current cost of utility fuel units coupled with base rates and maintenance costs will give one (assuming calculations are all correct) current utility bill totals. One needs to include both base rate charges and fuel adjustment costs in determining current utility rates per unit of energy delivered.

In order to determine the saving for a particular energy conservation package, the R value changes to the house must be determined and the new fuel needs determined. These calculated fuel savings compared to the total cost of the improvement (materials, labor, capital, and interest), will determine the payback period for the improvement. A set of payback periods in terms of years for energy conservation systems as considered for Dallas, Texas at 1977 utility prices are presented as a function of utility type for the most common forms of retrofit systems.

A detailed analysis of the energy conservation options as a function of most cost effective have been made for most of Texas, exclusive of the panhandle. As a result of this analysis, a two part retrofit package has been developed. These are a series of steps which can be taken for the most cost effective energy conservation steps one can take to reduce energy bills. These are presented in Table 8A, the basic package and Table 8B, the better package. If one is going to pay for all work to be done by outsiders, do the basic package first. If the homeowner can do the work himself or herself then all items in both Tables that they can do should be done first.

Typical annual energy use patterns for various types of residences are shown in Table 9. These average patterns should be used for comparative purposes in the activities and experiments discussed in this module. Taking these annual energy use patterns and multiplying by the average cost of power as shown in Table 10 one gets the average monthly bills in roughly 1977-79 dollars.

B. DEVELOPING YOUR OWN ENERGY CONSERVATION PRIORITIES

Energy conservation to be effective in any group, be it national, regional, local, or an individual home must be based on a consensus and a compatibility with the desired lifestyle. Therefore, before an energy conservation plan can be put into use, it must be prioritized and indexed with respect to individual wants. Out of this prioritizing and indexing procedure should come two lists. These lists should consist of all energy conservation options that are seen available to the group considering the possibility of reducing utility costs. The first list should have all desired or current activities in order of increasing importance to the individuals concerned with reducing or controlling their energy use. Namely, the items at the top of the list are those activities or energy uses which are least important and would be least likely to be missed if they were reduced or eliminated. The second list should catalog in descending order, from the highest energy use to the lowest

ergy use, the activities currently engaged in by the individual or group. is second list should then be modified consider which of the high energy uses are more amiable to the maximum reduction in energy costs while modifying with a mited impact the desired activities at the bottom of the first list. Obviously, all activities should appear on both lists. e first list which we will call the List Luxuries, having the most luxurious at the top and the least luxurious at the ttom. Those items which are most readily iminatable would be at the top of this ist. The second list will be the List of anking Energy Uses in that lifestyle. The econd list is important for two reasons:) it tells you which areas are large energy users and 2) it lets you know which these can be reduced with minimum cost. xample, if Item 1 on your luxury list is a totally frivolous item, which is of no portance to the household standard of iving and is readily eliminatable. Such things as electric can openers, or motorized orkscrew and bottle cap removers, etc. may e readily eliminatable, but may consume ittle energy and have only the consumed energy that is represented in the cost of urchase. The second list, which includes the high energy users at the top, will mean that if you have in the top of the ist significant fractions of your energy se in certain activities, then a ten percent cut in that activity's energy se can make a significant contribution the overall conservation effort while 00 percent reduction in an item at the bottom of the Ranking Energy Uses List, hat uses a very insignificant fraction the total energy, will have no impact on a conservation program and may not be ost effective at that point because the ost of eliminating that activity may exceed the total energy consumed by that tivity. This assumes one ignores the pital energy cost necessary to refine, manufacture, transport and otherwise provide the materials and facilities including pliances, etc. for that activity. This s very general. We will do some specific examples of these two lists to show what mean. Let's take the Luxury List first. ble 1 shows a generated luxury list that can be used for evaluation. Table shows a ranking list of energy users.

LIST OF LUXURIES

1. electric can opener
2. battery-powered carving knife
3. electric crepe dish
4. ornamental lights such as lava lamps and other electromechanical light display devices
5. decorative gas lights left on 24 hours a day
6. ornamental external lights that are used for decorative purposes
7. external yard light
8. electric cooking, top cooking appliances
9. microwave oven
10. electric clothes washer
11. electric clothes dryer
12. electric stove
13. refrigerator
14. lights and lighting system
15. cooling system
16. heating system
17. hot water system

LIST OF RANKING ENERGY USES - An Example From Houston, Texas

1. Space conditioning
2. Space heating
3. Cooking
4. Hot Water
5. Washing and drying
6. Lighting
7. Television-Radio-Home Entertainment-Electronic Equipment
8. External yard maintenance
9. Maintenance and improvement of property

Note that from these two lists all activities that are under consideration should be included. One could or could not place transportation and automobile use in this list depending upon whether energy conservation of that area is being considered at this time. In general, automobile use would be in the top third or top quarter of the energy use categories in the demand listing. Where it would appear in the Luxury List depends on how needed the car is or seems to be. For breaking down automobile use for conserva-

tion purposes, one should separate out the required employment travel from the travel that is used to maintain the residence, groceries, clothing, business, etc. and these two travel categories from that for pure entertainment and personal discretion travel for non-business or home maintenance use. The automobile has been left out of this example to simplify it because location of residence with respect to employment, shopping, etc. is an option that a person has only when moving and this of course is highly constrained by the location of the job and the demography of the surrounding community. But, anyone who is seriously interested in energy conservation over the long run should consider minimizing the miles and time spent in an automobile getting to and from places of employment and shopping.

By this time it should be obvious to all concerned that trade-offs from conservation methods are neither simple nor one-dimensional. The quality and quantity of the considered trade-off is of major importance in determining liability of consideration.

Assuming one has decided to conserve energy and assuming one has decided what lifestyle and level is desired, then decisions can be made on prioritizing the energy conservation methods with respect to time and cost of improvements as compared to ultimate benefits and economic savings. It should be said in general that in a market of increasing energy costs, one does make an investment by reducing the energy demand of a particular facility or lifestyle. Increased energy costs mean that with time, the capital cost of making eneryg conservation modifications will increase at least in proportion to the energy necessary to produce the materials used for the modifications. Prioritizing and indexing energy conservation options means that minimum money can be used to produce the maximum effect. This then frees the maximum amount of capital for use in the making of additional improvements in the near future. With time, the return on any investment of money and time in energy conservation will depend upon changes in the energy policy pricing structure..

The important point to be stressed in developing your own energy conservation priority system is that it should be designed to fit your own interests and lifestyle as much as possible. You have a certain amount of money which can be used and spent, within limits, to satisfy and maintain the desired lifestyle. Economics and political legislation will mandate a certain amount of energy conservation. The question will be whether you make your decisions in the areas of personal interest, when options are still there and the income flexibility is available, or whether these decisions must be made as a function of reduced energy or materials, increased costs, or shortages. In the latter case, one will get much less of a return for time and money spent on conservation options. The money spent on utility bills past the minimum levels required by a conservation philosophy within personal lifestyle limits is essentially discretionary money and should be considered as such in all priority conservation analyses. One must, with respect to money, realize that you can either give it to the utilities by overspending for energy, which is the same thing as burning money, or save it and spend it on something else which is needed or desired. This means that we can only gain by reducing energy demands and requirements while at the same time saving money and possibly improving lifestyles. The important thing is to remember that energy conservation does not mean denial of personal preferences. This should be stressed very greatly in the presentation of energy conservation, on the setting of priorities, and the developing of a personal conservation plan. The students are referred to the previous ten modules for more specific details.

A SUMMARY OF ENERGY CONSERVATION METHODS FOR VARIOUS APPLICATIONS AND ACTIVITIES

After considering the conservation aspects of all the models and specifics of this module, one can summarize in numerical form what the better conservation activities and lifestyle approaches are that help reduce energy costs and utility bills. In general, a customer benefits from energy conservation because:

1. cuts down on your utility and gasoline bills,
2. if you save energy, you help fight against pollution.
3. if you don't save natural gas, petroleum and electricity now, some day none may be available.

The energy conservation methods are grouped under specific appliances and uses. The first list is for general residential and small commercial use, and the second list is for industrial and business use. However, many of the energy conservation practices for business and industry are directly applicable to the home; especially people who have electrical-electronic and audio-visual equipment.

GENERAL RESIDENTIAL AND SMALL COMMERCIAL

Heating

1. In cooler months of the year, set your thermostat at 68° during the daytime, several degrees lower at night (an extra blanket on your bed can make up the difference).
2. Set your thermostat at a comfortable temperature, then leave it alone. . . turning it up and down wastes energy.
3. Make sure your home has adequate insulation -- install storm windows and doors if you don't have them. Three inches of insulation in attic can save as much as 25% on heating cost over no insulation.
4. Avoid frequent opening of outside doors. Use weather stripping to seal air leaks around edges.
5. In winter, keep your drapes open to let the sunlight in during the day, close them at night to stop cold drafts.
6. Keep the damper on your chimney closed when not in use.
7. Turn off heat vents and close off rooms that are not in use.
8. Keep filters clean . . . change them at least twice a year.
9. Consider a switch to solar heating in the future.
10. Remove furniture, rugs, etc., that block heating vents or radiators.
11. Place aluminum foil between radiator and exterior wall to reflect heat into the house.

Air Conditioning

1. During hot months, set your air conditioner on "low" or keep your thermostat at 72° or more . . . this way you'll use less electricity and feel less uncomfortable when you step outdoors.

2. In summer, close drapes to keep sunlight out (this makes it easier for the air conditioner to keep things cool).
3. If you have a window air conditioner, try to place it in the window with the most shade.
4. Use heat producing major appliances (dishwashers, dryers, ovens, etc.) during early morning or evening . . . not when your air conditioner is working the hardest.
5. Keep doors and windows closed when air conditioner is operating . . . and close off unused area.
6. Keep filters clean.
7. Set the thermostat higher if you are away most of the day and turn it off if you're going away for a weekend or longer.
8. Storm windows will help keep the cool air inside.
9. To ease the load on your air conditioning system, consider installing an attic fan to help blow out the trapped hot air.
10. Make sure sofas, bookcases and other solid objects do not obstruct your air conditioner to keep it from operating efficiently.

Hot Water

1. Set your water heater's thermostat at "medium".
2. Encourage showers instead of tub baths to save hot water.
3. Fix leaky faucets (a drip a second wastes 700 gallons a year).
4. Don't wash dishes under running water . . . a dishwasher uses much less hot water than washing dishes by hand.
5. Run washing machine, dryer, and dishwasher only with full loads. Wash clothes in cold water whenever possible.
6. When on vacation use the water heater's vacation setting. The pilot light will keep burning without using more energy to heat water.
7. Don't waste hot water. For example , don't leave water running while washing hands or shaving -- partially fill the basin first.

Lighting

1. Turn off lights when not needed.
2. Keep light bulbs and fixtures clean . . . that way you may require fewer bulbs.
3. When possible, use fluorescent lamps. A 40-watt fluorescent lamp produces more light than a 100-watt incandescent bulb.
4. Install dimmer controls to save energy and add atmosphere.
5. Rooms with pastel walls and a light-colored interior decor usually require fewer lamps.

Major Appliances - Stove

1. Partially thaw frozen foods before cooking.
2. Put small pots on small burners, large ones on large burners.
3. Cover pots to avoid heat loss.
4. Use high setting on units to start, then reduce heat and food will continue to boil.
5. When cooking with water, use as little as possible so food will heat quickly.
6. When using the oven, preheat only 10 minutes . . . and don't peek. The oven uses less energy than the stove top because it is a confined space.
7. Avoid using aluminum foil on shelves directly under pans since it can reflect the heat away from them.

8. Cook by time and temperature. A meat thermometer can eliminate over-cooking. Precise timing eliminates wasted heat by peeking.
9. In summer, cook outdoors whenever possible to reduce heat build-up inside. Experiment with a solar cooker.
10. When using gas, regulate burners so flame tips just touch utensil bottoms.
11. A clean oven and broiler cooks more efficiently.
12. Ceramic, glass and stainless steel are best heat retainers (lower oven temperatures by 25°).

Major Appliances - Refrigerator/Freezer

1. Locate refrigerator out of sun and away from heat sources (stove, dishwasher, etc.)
2. Cool foods to room temperature before placing them in refrigerator.
3. Make sure gasket seals door well.
4. Defrost freezer when 1/4" of frost has built up.
5. Keep freezer full, but no overloaded: it uses less energy to keep freezer cold when air can easily circulate around packages.
6. Chill food before placing it in freezer . . . an don't freeze too many things at once.
7. A chest freezer is more economical than an upright because when the door is opened the cold air settles on the bottom, rather than flowing onto the floor.
8. To avoid excess cold loss, open refrigerator or freezer only when necessary.
9. Check the temperature setting of your refrigerator and freezer against your appliance manual. If you store your food too cold, you will be wasting energy.
10. When preparing to go on vacation, set refrigerator at a warmer temperature and leave it fairly empty.

Major Appliances - Washer & Dryer

1. Keep the lint traps clean to assure top efficiency.
2. Use only when full and as cool a setting as possible (DO NOT OVERLOAD).
3. Use the water level control on your washer . . . small loads require less hot water.
4. Don't overdry clothes. Save ironing by hanging or folding clothes as soon as they are dry.
5. Your dryer should be located where it has easy access to clean dry air.
6. Use the free solar energy outside whenever possible.
7. Soak stubborn stains before washing.
8. Check type of soiling and fabric -- when possible wash clothes in cold water (except diapers).

Transportation

1. Reduce the amount of driving you must do . . . instead of 5 or 6 short trips make one well-planned and organized trip.
2. Use car pools to get to work, take kids to school, or even for shopping trips.
3. Use public transportation whenever possible.
4. Use a bicycle for short trips . . . uses less energy and keeps you in shape at the same time. Or walk.
5. Consider buying a smaller, more efficient car.

Automobile

1. Avoid jack rabbit starts and sudden stops to save gas.
2. Weaving in and out of traffic wastes fuel and can cause needless accidents.
3. Don't waste gasoline by keeping your car running while waiting for someone.
4. Try to hold a constant speed when possible.
5. On hot summer days, park in the shade so the air conditioner doesn't have to work as hard. When possible, drive with the windows open instead of using the air conditioner.
6. Keep your car in top shape . . . have it tuned regularly.
7. Make sure your tires are properly inflated so you get better mileage.
8. If you are a 2-car family, use the smaller one for running errands.
9. Change oil and oil filters every 3,000 to 6,000 miles (according to your owner's manual). A dirty engine wastes gas.
10. Improper wheel alignment cuts down on power, gas mileage and tire mileage!

Appliances - General

1. Follow detergent directions carefully, oversudsing in both dishwashers and washers uses extra energy, because the equipment has to work harder.
2. Use small appliances where possible, rather than large ones. For example, an electric fry pan uses less energy to cook a one pot meal than an electric range.
3. Iron all clothes at the same time to avoid reheating iron later in day or several times in one week.
4. Have gas appliances cleaned regularly so they will always operate at top efficiency.
5. Motor driven appliances, like mixers, are particularly economical.

General

1. Color TV's use more energy than black and white TV's.
2. Always turn off a radio, TV, or record player when no one is watching or listening.
3. When possible use your major appliances during off-peak hours (before 8 a.m. and after 6 p.m.), when commercial and industrial use is less.
4. Keep your swimming pool in top operating condition so it doesn't waste energy.
5. Recycle aluminum, paper, and glass whenever possible.
6. Watch how you water your lawn . . . a lot of water is wasted when a lawn is saturated and the water starts running into the street.
7. Avoid using extension cords for major appliances and don't overload circuits. Overloading causes reduced energy efficiency.
8. Make your family aware of the energy problem and what they can do about it!

INDUSTRIAL AND BUSINESS

Heating

1. Make sure sufficient insulation is installed.
2. Do not overheat areas . . . keep the thermostat set at 68° or slightly lower during the winter. (66-70° is recommended for factory areas, 72-74° for general office areas.)
3. Cut heat leakage from building by using caulking and weather stripping around doors and windows.
4. Make sure heat is not left on too far into spring.
5. Reduce or turn off heat in unused areas (warehouses, docks, etc.).
6. Have a control on outside doors so they are not left open during the winter. . . heating the outdoors.
7. Reduce heating during those times when the space is unoccupied.
8. Check with equipment suppliers or qualified engineers to determine the extent to which your heating, ventilating and air conditioning equipment is suited for its job . . . is it the best?
9. Consider the practicality of infra-red heaters in high bay areas and warehouses. (It requires less fuel than other kinds of heating because it only heats solid objects in its path . . . not the air in between.)

Cooling

1. Do not overcool areas . . . keep the thermostat set at 72° or higher during the summer.
2. Spraying water on building roofs can reduce the effect of solar heat in warm weather.
3. Close off unused areas that do not require cooling.
4. Control outside doors so they are not left open during the summer. . . cooling the outdoors.

Maintenance

1. Emphasize boiler maintenance. Cleanliness improves its operation.
2. Check stack temperatures to make sure you are getting complete combustion.
3. Check the insulation on heat/cold pipes -- do machines have to work extra hard because of leaks or a lack of proper insulation.
4. Inspect heat transfer surfaces regularly to make sure they are clean . . . insuring top efficiency.
5. Be on the alert for hot spots and deterioration in furnaces and pipe systems. (Air leaking into furnaces can cause large losses.)
6. Make sure furnace controls and burners are maintained fore best efficiency.

Electricity

1. Turn off lights in empty rooms except where needed for safety and security (i.e. washroom lights).
2. Where possible use fluorescent lighting rather than incandescent bulbs (you get more lighting for less watts).
3. Turn off electrical equipment when not in actual use (i.e. typewriter while you're on the telephone).

4. Check and justify weekend electrical power usage.
5. Are motor actuating controls in proper condition so that motors don't operate unnecessarily?
6. Install automatic controls for outdoor and indoor lighting so electricity is not wasted when it is not needed.
7. Convert to higher voltage electrical systems where practical.

Transportation

1. Reduce amount of driving necessary . . . instead of many short trips organize errands into one well-planned and organized trip.
2. Encourage car pools and the use of public transportation.
3. Whenever possible ship freight by railroad rather than by air . . it requires less energy.
4. Keep company cars and trucks in top-shape . . . have them tuned regularly.

Operations

1. Avoid short runs on thermal process equipment when possible and shut down or idle equipment during production interruptions.
2. In many areas, energy waste is often the result of long unquestioned plant practices that can be shown to have no effect on employee performance or product dependability . . . re-evaluate.
3. Schedule loads so equipment operates at the top level of efficiency.
4. If possible, reschedule some electrical usage to off-peak periods when voltage remains high. (Before 8 a.m. or after 6 p.m.)

General

1. Waste heat from burner stacks and industrial processes can often be recovered and used.
2. Recycle waste materials (sawdust, oil, etc.) as supplemental fuels where possible.
3. Consider the use of heat pipes for transporting required heat or dissipating unwanted excess heat.
4. Check for accuracy of deliveries of oil, gases, etc.
5. Investigate "new" forms of energy.

These lists were developed using material from the Edmund Scientific Company Manual No. 9903.

MODULE #11

ECONOMIC OF ENERGY CONSERVATION

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TABLE 5

ENERGY COSTS AND EFFICIENCY OF CONVERSION

I) Heat Content of Fuels

Electricity	3412 BTU/KWHR
Natural Gas	1050 BTU/Ft^3
Coal	1310 BTU/Gal.
Oil	141,000 BTU/Gal.

II) Equipment Efficiencies

	Recommended New	Usual & Average	If Known
A) Cooling			
(1) Electric	2.05	1.47	EER/3.412
(2) Gas Absorption	.48	.27	COP
B) Heating			
(1) Electric Resistance	1	1	1
(2) Electric Heat Pump	2.25	2.25	SEASONAL PERFORMANCE
(3) Furnace (gas)	.75	.55	EFFICIENCY

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Tab E

(321)

PAYBACK PERIODS FOR RETROFIT ENERGY CONSERVATION SYSTEMS FOR DALLAS, TEXAS (1977)

Type of Work	Time in Years			
	Heat Pump	Electric Resistance	Gas	Oil
Add storm sash	12	7	16	6
Add 6" insulation to uninsulated attic	3	2	3	2
Increase 3 1/2" insulation in attic to 6"	7	5	8	5
Blow 3 1/2" into sidewalls	12	8	14	8

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Table 8A

RETROFIT PACKAGE

Texas - exclusive of Panhandle

ZONE I

BASIC PACKAGE

INSTALL DAY/NIGHT CLOCK THERMOSTAT

ADD CEILING INSULATION TO ACHIEVE TOTAL OF APPROXIMATELY R-19

TUNE-UP FURNACE AND AIR CONDITIONING SYSTEM

WEATHERSTRIP EXTERIOR DOORS

SEAL ALL OPENINGS AND CRACKS IN EXTERIOR WALLS

CALIBRATE WATER HEATER TEMPERATURE

WEATHERSTRIP AND INSULATE ATTIC ACCESS DOOR

INSPECTION OF ENTIRE HOUSE FOR ADDITIONAL RECOMMENDATIONS

Table 86

RETROFIT PACKAGE

Zone 1 - Exclusive of Panhandle

BETTER PACKAGE

ADD CEILING INSULATION TO ACHIEVE TOTAL OF APPROXIMATELY R-22

INSTALL R-11 FLOOR INSULATION ABOVE UNCONDITIONED SPACES

TAPE DUCT JOINTS AND INSULATE DUCTS IN UNCONDITIONED SPACES

INSTALL STORM WINDOWS IN ALL LIVING AREAS

BLOW INSULATION IN UNINSULATED EXTERIOR WALL CAVITIES

ADD OR INCREASE NATURAL ATTIC VENTILATION, IF NECESSARY

INSTALL CEILING FAN FOR SUMMER COOLING

TYPICAL ANNUAL ENERGY USE PATTERNS
VARIOUS RESIDENTIAL CUSTOMERS
(ALL FIGURES IN KWH, EXCEPT FOR GAS APPLIANCES AS NOTED)

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
COMFORT CONDITIONING INCLUDING:					
AIR CONDITIONER					
ROOM	650	1,389	2,100	--	--
CENTRAL	--	--	--	3,200	2,650
HEATING					
FURNACE - GAS (CCF)	(C.M.)[1]	(960)	(1,250)	(1,895)	--
FURNACE MOTOR	--	400	600	1,500	400[2]
ELECTRIC BASEBOARD	--	--	--	--	20,400
ELECTRIC AIR CLEANER	--	--	--	216	216
ATTIC FAN	--	--	--	291	--
WINDOW FAN	--	170	170	170	170
DEHUMIDIFIER	--	--	--	377	377
HUMIDIFIER	--	113	163	213	163
HEATING PAD	10	10	10	10	10
ELECTRIC BLANKET	--	147	147	147	147
TOTAL COMFORT CONDITIONING:	660	2,229	3,290	6,124	24,533
APPLIANCES:					
RANGE					
ELECTRIC	--	22[3]	900	900	300[4]
GAS (CCF)	(C.M.)[1]	(90)	--	--	--

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
Microwave oven	--	--	--	--	300
Dishwasher	363	--	363	363	363
Toaster	39	39	39	39	39
Mixer	13	13	13	13	13
Coffee Maker	106	106	106	106	106
Blender	--	--	15	15	15
Disposal	--	--	30	30	30
Hotplate	90	90	--	--	--
Frying Pan	--	186	186	186	186
Broiler	--	--	--	100	100
Deep Fryer	--	83	83	83	83
Waffle Iron	--	22	22	22	22
Trash Compactor	--	--	--	50	50
Sandwich Grill	--	--	--	33	33
Roaster	--	--	250	205	205
Carving Knife	--	--	3	3	3
Total Appliances:	611	539	1,965	2,148	1,848
Food Preservation:					
Refrigerator					
12 cu. ft.	728	--	--	--	--
14 cu. ft. - frostless	--	1,829	1,829	1,829	1,829
Freezer					
15 cu. ft. - frostless	--	--	--	1,761	1,761
Total Food Preservation	728	1,829	1,829	3,590	3,590

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
LAUNDRY:					
WRINGER WASHER	--	76	--	--	--
AUTOMATIC WASHER	--	--	103	103	103
DRYER					
ELECTRIC	--	100[3]	100[3]	993	993
GAS - WITH PILOT (CCF)	--	(65)	--	--	--
GAS - ELECTRIC IGNITION (CCF)	--	--	(45)	--	--
IRON	144	144	144	144	144
WATER HEATER					
ELECTRIC	--	--	--	--	4,800
GAS (CCF)	(C.M.)	(325)	(325)	(325)	--
TOTAL LAUNDRY	144	320	347	1,240	6,040
ENTERTAINMENT:					
RADIO(S)	86	86	172	172	172
STEREO	--	109	109	109	109
T.V. (B&W)	--	--	362	362	362
T.V. (COLOR)	502	502	502	502	502
TOTAL ENTERTAINMENT	588	697	1,145	1,145	1,145

APPLIANCES NORMALLY IN USE	APARTMENT	SMALL HOME	AVERAGE HOME	LARGE HOME	ALL ELECTRIC HOME
HOUSEWARES:					
CLOCK	17	34	51	51	51
SEWING MACHINE	46	46	46	46	46
VACUUM	11	11	11	11	11
MISCELLANEOUS	15	55	56	165	81
TOTAL HOUSEWARES:	89	146	164	273	189
LIGHTING:	180	240	360	480	360
TOTAL ELECTRIC	3,000 KWH	6,000 KWH	9,000 KWH	15,000 KWH	37,500 KWH
TOTAL GAS	--	1,440 CCF	1,620 CCF	2,200 CCF	--
CONSUMPTION STATISTICS					
ANNUAL USAGE - ELECTRIC (KWH)	3,000	6,000	9,000	15,000	37,500
- GAS (CCF)	--	1,440	1,620	2,200	--
AVERAGE MONTHLY USAGE - ELECTRIC (KWH)	250	500	750	1,250	3,125
- GAS (CCF)	--	120	135	185	--
AVERAGE MONTHLY BILL - ELECTRIC	12.50	22.25	31.25	48.50	89.00
GAS	--	22.00	25.25	33.50	--
TOTAL	12.50	44.25	56.50	82.00	89.00